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Analysis Plan for

NARROWBAND/NARROWBEAM
AMBIENT NOISE (U)

Tetra Tech Report No. TT-A-836-76-285

NOVEMBER 12, 1976

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ANALYSIS PLAN FOR NARROWBAND/ NARROWBEAM AMBIENT NOISE (U)

8

November 12, 1976

12 20 p.

The Long-Range Acoustic Propagation Project
NORDA, Code 600
Contract No. N00014-76-C-1146 - new

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Tetra Tech, Inc.
1911 North Fort Myer Drive
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CONTENTS

I. INTRODUCTION (U)

(U) In this section Tetra Tech presents its proposed analytic approach to the study of narrowband ocean noise with emphasis on its potential impacts on current and future systems analysis and design. The Tetra Tech plan suggests specific system-oriented goals for consideration.

DEFINITION OF THE PROBLEM (U)

(C) Traditionally, the acoustic modeling and measurement program conducted by LRAPP has concentrated on two aspects of acoustic environment characterization: estimation/prediction of the energy level output of the beamformer due to a point source signal propagating between a given point and the receiving array; and analyzing the ambient noise amplitude spatial distribution for specific band-limited frequencies, typically 1/3 octave segments. When narrowband noise has been investigated, it has normally been at least 1 Hz in bandwidth, although there have been more frequent uses made of narrowband bandwidths lately, on the order of 1/10-1/Hz. The noise has been characterized in terms of its most elementary statistical properties, that is, its mean value almost exclusively, in these bandwidths.

(C) Among the systems being introduced into operation or in advanced stages of R&D currently are SPEAR, SIMS (Signal Imaging and Measurement System), and SVAA (Super Vernier Auto Alert). Generically speaking, these systems include such features as very narrow bandwidths (on the order of a few mHz), line trajectory formation, and automatic threshold counting and decision processes. In the case of such narrowband detection, it is likely that narrowband lines from merchant shipping may constitute a major portion of the ambient background, even to the point of appearing flat in a sufficiently narrow bandpass. The impact of such cases upon narrowband noise statistics and detection performance is of great interest. Since such signals may in fact comprise the dominant features of the noise background.

(C) Because these narrowband noise features have not been studied sufficiently it is not now possible to model adequately the performance of some important new techniques in surveillance processing. Although LRAPP does not study the signal and noise outputs of any particular processor, it is chartered to study the ocean environment as it relates to surveillance processing. It is necessary to utilize generic knowledge of processor functions appropriately to characterize environmental effects as they may impact the develop or performance of surveillance processing systems.

(C) We now are seeing the introduction of receivers which actually count the number of times the signal is detected above the threshold before making a decision that a signal is present. Such sequential detector receivers are clearly not amenable to simple SNR characterization.

(U) Analysis of their performance can better be accomplished through the calculation of maximum likelihood ration (MLR) statistics. The likelihood ratio is of the form

$$\Lambda(\underline{R}) = \frac{P_{\underline{r}|H_1}(R|H_1)}{P_{\underline{r}|H_0}(\underline{R}|H_0)}$$

where $\underline{R}$ represents the observed signal vector and $P_{r|H_i}$ ($\underline{R}|H_i$) typically is the probability that a signal is present (hypothesis H_0) given the observable R. Its calculation requires a complete knowledge of the probability density functions of both noise alone and signal plus noise.

(U) This statistical analysis is intrinsically different from that observed in an operations research type of model in which distributions are given to hypothetical processor outputs in order to imbue the sonar equation with statistical variation; rather these are the actual statistics which determine the statistical performance of a decision threshold receiver, the probability distributions from which receiver operating characteristic (ROC) curves are derived.

(U) Thus, it is not sufficient to know merely the average signal-to-noise ratio out of the beamform in order to set detection thresholds. The actual probability distributions must be known in order to reasonably estimate the performance and to optimize design of such receivers.

(U) In addition to these pdf considerations, the implementation of actual detectors which are designed to be optimum will require detailed knowledge of signal and noise structure. Such detectors will utilize some form of a matched filter or correlation detection technique, which in turn requires a knowledge of the desired signal time waveform or frequency spectrum as it appears at the input of the detector, and a description of the noise as it differs from white Gaussian.

GENERAL ANALYSIS APPROACH (U)

(U) In accordance with the questions posed in the "Realizable Objectives" section a general analysis approach for LRAPP is recommended in this section, with a specific subset of this program proposed for the following year to be performed by Tetra Tech.

(U) Figures 1 and 2 present graphical descriptions of the recommended analysis approach for a system-oriented analysis program. Figure 1 describes the approach from a flow-chart point of view. This approach utilizes an understanding of ambient noise and propagation loss theories and develops hypotheses regarding narrowband noise relative to system design and environmental predictions. At that point, we will be able to define a data base subset, and proceed to perform noise descriptor measurements relating to the hypotheses. The next task is the development of mappings from environmental variables to the noise metrics. These relationships will then be developed and refined, with emphasis on those that promise particular operational utility. The final result will be specific impact upon design and/or performance prediction.

(U) A more graphical illustration of this process is given in Figure 2. As seen in Figure 2, there are two independent functions which must be initiated: the selection of environmental variables (used hereafter in a generic sense encompassing source and receiver as well) and the selection of operationally usable clustering metrics.

(U) In June 1976 the LRAPP sub-panel rreport on ASW System Requirements recommended that a rational basis for general statements which relate ambient noise characteristics to the environment be developed. This goal is represented in Figure 2 by the mapping of a relationship from a set of environmental variables to a set of statistical descriptors of noise (narrowband noise in the present case). Environmental variables might include wind speed, season, surface temperature, etc., or might also include system variables such as beamwidth, whereas the noise descriptors would be the standard statistical characteristics such as mean, variance, probability density function (pdf), etc.

(U) Correspondingly, potential discriminants of the signal and noise are examined for their amenability to extraction of signals from noise by clustering in a decision space as in classical pattern recognition or signal detection problems. A set of metrical descriptors or measures is thus identified. Typical measures might be signal duration, frequency, or coherence.

(U) In the cases where a correspondence can be set up between the metrics and noise statistics, a high interest subset will be defined. This subset of pairs might include such pairs as amplitude for a metric and mean value for the corresponding statistical characteristic.

(U) The hypothesis would relate to the objectives described later, an example being that it is possible to relate signal and noise coherence to range. Such an hypothesis would result in the collection of phase statistics at different ranges.

(U) In those cases where associations are possible, the analysis effort would be concentrated in order to develop and refine the mapping relationships between the environment and the characteristics. Also, those metrics which are of the greatest operational utility would receive the greatest attention, and would ultimately result in specific system design impacts.

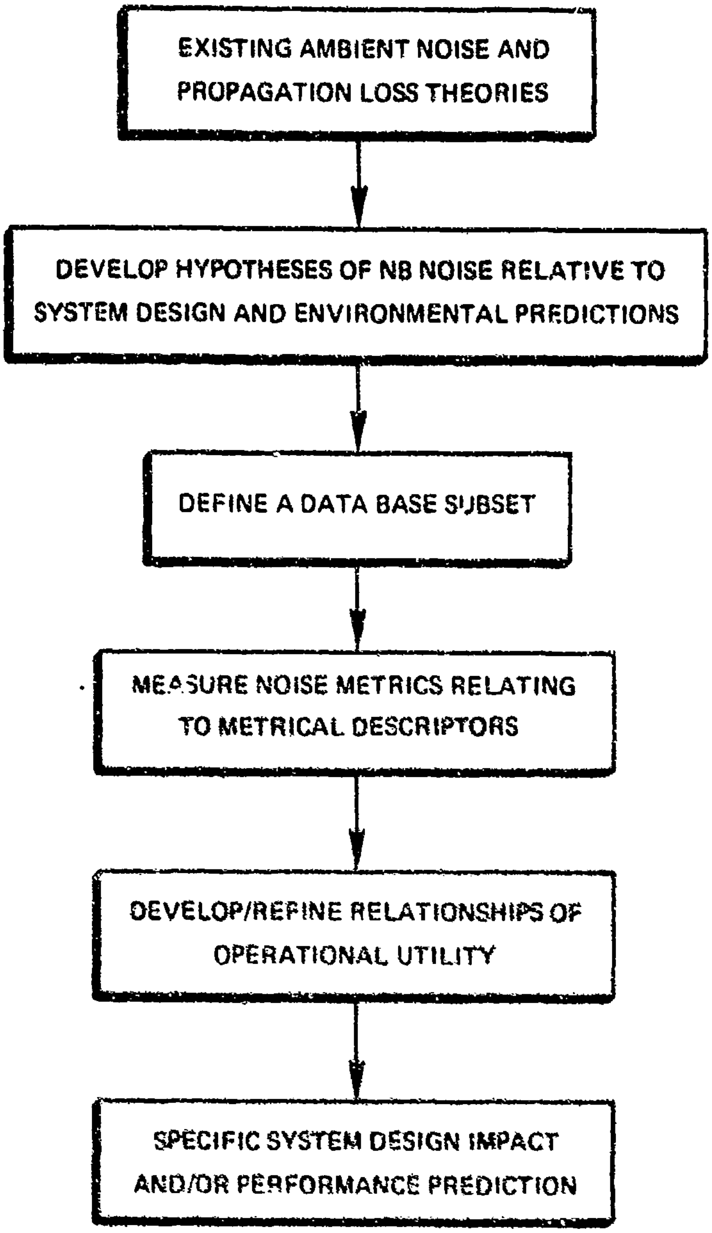

Figure 1. OUTLINE OF GENERAL METHODOLOGY (U)

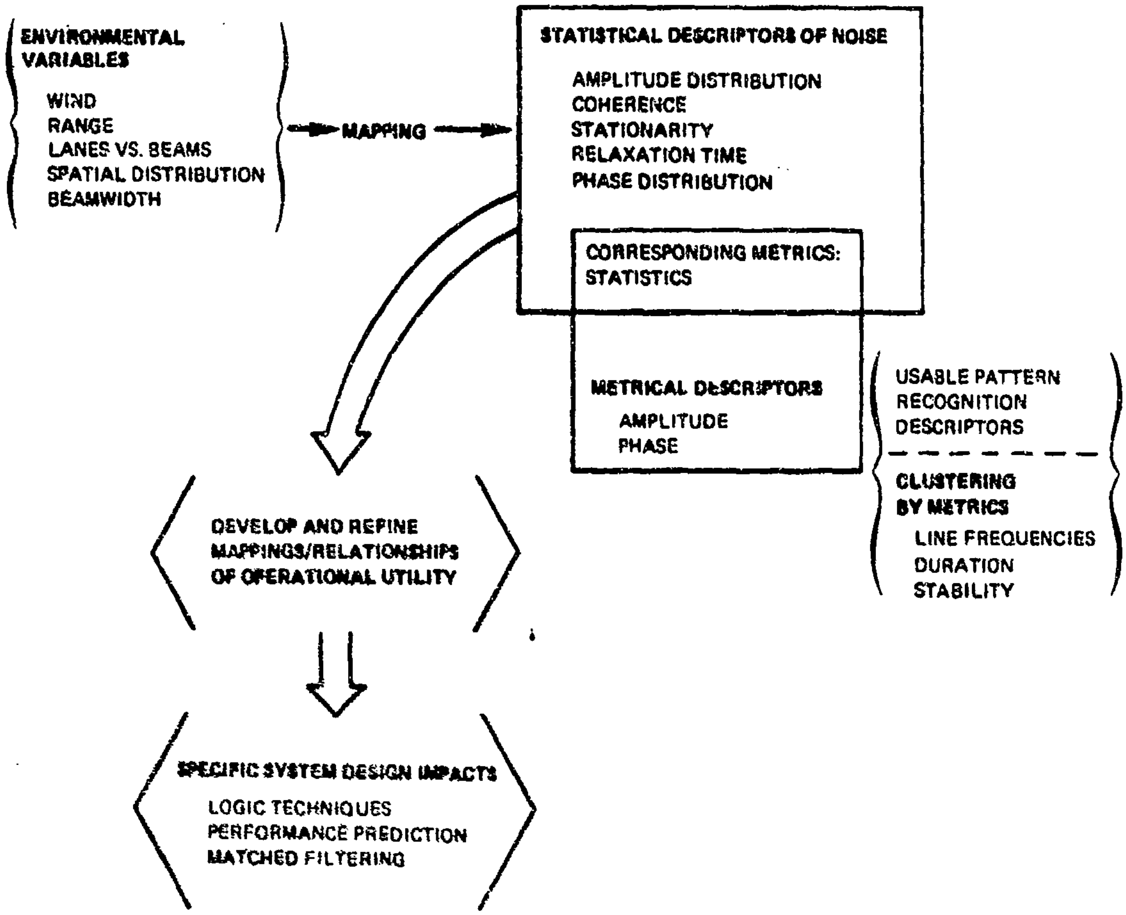

Figure 2. SYSTEM ORIENTED NARROWBAND NOISE/ENVIRONMENT ANALYSIS (U)

(U) Specific analytical functions related to the above processes will be described in detail in Section 2, Methodology. In general, it can be stated at this point, that estimating probability distribution functions (pdf's) is one of the prime objectives of the effort. Data will be collected in appropriate narrowband analysis bandwidths, and histograms generated, pdf's will be estimated from the histograms. This will be done for both amplitude and phase of spectral data which has been chosen to be consistent with the bandwidths expected in actual systems. The development of such pdf descriptions will lay the base for eventually determining or predicting the performance of actual systems in terms of probability of detection and false alarm, and to be able to construct receiver operating characteristic curves for the actual ambient noise.

(U) In addition to this system performance utility, fine-grain looks at the noise, both in terms of statistical characteristics and spectral estimation, will have a direct impact upon the design of noise spectrum equalization techniques (NSE), automatic line integration (ALI), and adaptive filtering.

REALIZABLE OBJECTIVES FOR A NARROWBAND/ NARROWBEAM NOISE STUDY (U)

(U) A number of specific recommendations can be made regarding the evolution of LRAPP data analysis as it relates to the analysis and design of acoustic signal processing systems. These recommendations will be set within the framework of a list of objectives that are posed as answerable questions. It is felt that this set of questions will be useful to illustrate the specific gaps in information and to identify potential results that can be realistically accomplished. These questions have been divided into categories, each of which is elaborated upon in Section 3:

- Statistical description
- Environmental variables
- Clustering metrics (potential pattern recognition measures)
- Mapping relationships, environment to noise description

(U) The following questions are proposed as being relevant to the problem as it has been expressed, and being within the realm of feasibility for obtaining reasonable answers in a realistic analysis effort.

Statistical Descriptions of Noise (U)

(C) 1. What is the statistical description of the noise within narrow bandwidths, such as are anticipated in upcoming operational systems? What are such statistics (explicitly the probability distribution functions) for the cases when narrowband shipping noise is present and when it is thought to be dominant? Over what range of bandwidths can the distributions be inferred from each other? Is it possible to make any statements regarding the stationarity of such narrowband noise?

(U) 2. What can be determined from an analysis of noise spectral microstructure which will result in improved noise spectrum equalization (NSE) designs, adaptive filter and adaptive beamformer designs, the development of matched filter detection techniques, and pattern recognition techniques? What processing advantages can be garried using existing bandwidth estimators to examine the spectral microstructure?

(U) 3. What is the temporal coherence (frequency and phase stability) of narrowband noise which is dominated by shipping lines? In non-stationary noise environments should structure functions be used to gauge coherence instead of autocorrelation functions? If so, what are the criteria for use of these functions in regard to nonstationarity?

Environmental Variables (U)

(U) 4. What general relationships can be established between narrowband noise probability distributions and specific characteristics of the environment? (An example would be the effect of wind on ambient noise, as is being investigated in the WINE experiment at the ARC.)

(U) 5. What is the coherence of narrowband lines as a function of range?

(U) 6. Is it possible to characterize shipping lines as a function of shipping density or of beam angle with respect to shipping lane direction?

Clustering Metrics (U)

(U) 7. Does the environment permit the use of metrics other than line frequencies which could be useful in detection/discrimination? Are there metrics which would be useful in pattern recognition and decision space clustering algorithms? An example might be signal duration vs noise line duration above a threshold.

(U) 8. Do the noise statistics in nearby spectral bins differ sufficiently so as to aid in line resolution?

(C) 9. Are there characteristics of non-target lines which make "logic" techniques especially useful for interference suppression and which may affect the selection and implementation of the techniques? (SPEAR is currently employing a form of this method in its coincidence filtering but no rational basis exists for relating noise characteristics to its threshold parameters.)

Environment to Noise Mapping (U)

(U) 10. Are the range/frequency boundaries of the JASONs (MUNK *et. al.*) theory of propagation applicable to interference noise modelling? what can be inferred from LRAPP data regarding so-called saturated and unsaturated fluctuations versus range and

frequency? (Such information may be useful in separating path loss and fluctuations from source fluctuations.)

(C) 11. Are there cases in which the spatial distribution of interference/noise sources is such that the beam statistics of narrowbeam arrays (beamwidths on the order of those of LAMBDA) differ significantly from those of more broadbeam arrays, such as SOSUS or TASS, over the processing time intervals and analysis bandwidths of various surveillance signal processors? At such narrow beamwidths do so-called spatial noise holes become significant so as to improve detection performance beyond that predicted by using homogeneous noise models? In the narrowband case, does the beam output become more temporally coherent for narrowbeam outputs than for broadbeam outputs (which may include the summation of several spatially localized noise sources)?

Other (U)

(U) 12. Question 11 can also be asked about signal statistics. To what extent can the LRAPP data base containing calibrated source signals support such characterization to detection of fading signals in non-stationary narrowband noise?

2. RECOMMENDED TETRA TECH TASKS (U)

(U) Tetra Tech proposes to undertake the tasks listed below in FY 1977. The Objective numbers correspond to the questions posed under "Realizable Objectives" in Section 1. These tasks could be performed under a task-ordering agreement.

Task 1a—Narrowband ACODAC Data Analysis from Church Opal (U)

(U) (Objectives 1, 2, 3, 4, 5, 7, 9) Analyze the ACODAC hydrophone data. concentrating on a specific time segment of data containing known merchant lines. Perform narrowband spectral analysis and statistical processing as described in Section 3, Methodology. The ACODAC data analysis will serve as the baseline analysis for the overall effort. the specific data set recommended for this baseline task is held by the University of Texas, Applied Research Laboratory. Well documented merchant line structure is available from these data. Since the geographic scenario is well defined, the amplitude statistics can be thoroughly investigated. Since preprocessing (digitizing and FFT) has been done on much of the data, it is a particularly efficient way to realize some of the objectives of the narrowband noise effort.

Task 1b—Church Opal 11 September Data Analysis (U)

(C) (Objectives 1, 2, 3, 4, 10) Perform similar analysis of Church Opal data for the SOSUS beams and LAMBDA data recorded on 111330Z Sep, the time of cpa for one of the above merchants relative to the ACODAC array. This analysis will be performed within frequency bands of operational significance. Compare the results with Task 1a above and make appropriate inferences regarding environmental relationships. Using the Church Opal Exercise Plan, beam recordings have already been identified which will intersect recordings of one of the Church Opal ACODAC arrays. Highly significant comparisons can be made between the line statistics for nearby direct-path signals and paths on the order of 1000 miles. The LAMBDA array will show both a towed source and a merchant at almost identical bearings. Appropriate beamforming can be done by NRL to have both sources on the same beam. This is a key comparison for determining environmental relationships affecting merchant line-structure interference (noise). Using some runs from a model like the parabolic equation (PE) model for propagation loss, inference would be made regarding observed and predicted propagation induced fluctuations.

Task 2a—Investigation of Effect of Spatial Noise Non-homogensity Upon Beam Statistics (U)

(C) (Objectives 1, 3, 4, 5, 11) Within narrow processing bandwidths on the order of 10 mHz to 500 mHz, compare noise statistics on a spatial basis for various beamwidths. This will be accomplished by comparing LAMBDA and Centerville Beach beam outputs in which noise fields are chosen to be as similar as the data will permit. The Church Opal data base will be used. The different beamwidths available from broadside to endfire will be used to achieve beamwidth variation if the spatial noise distribution permits. Optionally, partial array digital beamformed data might be obtained from the raw sensor LAMBDA data from Church Opal, with varying beamwidths for a common noise field obtained in this manner. In all cases an attempt to assess the effect of range variation upon the beam output statistics will be made. Rather than attempting to deconvolve the array beam pattern from the spatial noise distribution in azimuth, the inherent combination of main and conjugate beams as a sum will be used for the assessment. Amplitude and phase distribution statistics and noise/interference coherence will be determined, parametrized on beamwidth and bandwidth. The data to be analyzed will be selected so as to gain as much knowledge as possible regarding the statistical variation between beam outputs associated with noise/interference "hot spots" and "holes."

Task 2b—Analysis of Selected FME Data (U)

(C) (Objectives 1, 2, 3, 4, 11) Make use of narrowband spectral data which will be produced by IBM during their post-experiment analysis. This will include spectra on the order of tens of mHz in bandwidth, and will be from the CVB and LAMBDA arrays, Towed source, merchant lines, and target of opportunity data will be available. The towed source is well defined in level, bandwidth, modulation and position (recordings at the source exist for this). The environment is similarly well defined. Comparisons similar to those of Task 2a will be made here using the PE (parabolic equation) model for propagation loss. "Piggybacking" the IBM post-analysis processing of FME data would provide a cost-effective approach.

Task 3a—Investigation of Risks, Issues, and Obstacles in Ambient Noise Statistical Prediction Models (U)

(U) (Objective 10) Work under this task would be focused on defining the statistical noise modeling problem using data analysis from Task 1 or Task 2, existing propagation models, and existing theories of fluctuation. The problem of modeling the narrowband low frequency noise seen by various arrays would be structured in detail. This study would encompass source model dynamics, channel modeling techniques, and the normal mode, parabolic equation and geometric optic models for propagation loss as

candidate elements in a statistical noise model. It would identify the current body of thought on problems associated with non-stationarity, and on the driving forces for low frequency fluctuations ($<$ 100 Hz) under a variety of ocean areas and geometrics. It would then summarize the risk and issues surrounding development of a narrowbeam and/or narrowband statistical noise model and finally; it would provide a suggested step by step plan for this model development.

Task 3b—Future ARC/LAMBDA Experiment Definition (U)

(C) (Objectives 6, 8, 9) Structure an experiment using either the ARPA Research Center (ARC) or LAMBDA (or a combination) for FY 1978, appropriate for furthering the results obtained from the analyses in Tasks 1, 2, and 3a. Because review of the existing data base has indicated that more data will be needed to meet Objectives 6, 8, and 9 in Section 1, a follow-on experimentation will be desirable. Use of the LAMBDA System and the ARC would enable beam selection to be performed so as to provide better control on key environmental variables. For example, such an experiment would present the opportunity of obtaining data from beams at different angles to shipping lanes (Objective 6). In order to verify and generalize the tentative conclusions derived from the earli[illegible] tasks, supplementary data must be obtained under controlled conditions, i.e., chosen [illegible] as to vary key environmental variables. The ARC and LAMBDA provide excellent resources for such an effort.

Task 4—Church Opal 14 September Data Analysis (U)

(C) (Objectives 1, 2, 3, 4, 6, 7, 10) Perform analysis of Church Opal all-array data in a manner outlined in Section 3, Methodology, for the day of 14 September. This is a day for which the merchant environment has been extensively documented. It is proposed that raw LAMBDA data be digitized and beamformed at NRL in chosen subsets of the ω-k plane to give selected beams looking into and away from the area of highest shipping density. Statistics would be collected on these two-dimensional samples. Using these data it would also be possible to give average number of interfering lines appearing on a beam which may complement beam occupancy studies already underway.

3. METHODOLOGY (U)

(U) In this section we discuss the general methodology and analytical tools that will be applied to the selection of components of the LRAPP data base. The initial work is not envisioned as a stand-alone effort since the problems are of such complexity, but rather it is planned as an initial thrust which should provide the basis for further systems-oriented work by the entire LRAPP community. Further, in light of the objectives proposed earlier, it is felt that with the wide range of potential resources available, including the LRAPP data base, the ARC, LAMBDA, and the various processing and analysis systems developed by the LRAPP community, that the tools available are adequate for a reasonable attack upon the problem.

(U) The methodology to be applied will consist of the following:

- continuing assessment of the LRAPP data base,
- examination of the ARC and LAMBDA as a collection and analysis resources,
- setting of goals and hypothesis verification, and
- utilization of specific analytical and statistical techniques.

The analytical and statistical techniques to be utilized are described below.

PRINCIPLE ANALYTICAL AND STATISTICAL TECHNIQUES (U)

Data Base Analysis (U)

(U) The investigation of the LRAPP data base started in FY 1977T will continue on an ongoing basis, although initial concentration will be focused upon the first data set selected for in-depth analysis, the ARL ACODAC data. Additional data segments will be selected for analysis (from the ARL data with the merchant lines). A primary problem here will be the resources needed from LRAPP to digitize some of the DAPAAN recordings.

Narrowband Spectral Analysis and Statistical Analysis (U)

(U) Initially, use will be made of the existing narrowband spectra (approximately 0.15 Hz resolution) which has been produced by ARL. These spectra are particularly useful at the outset as they are calibrated in terms of source level in micro-pascals. The accompanying time series will also be spectrum analyzed at other resolutions with the

ARL spectra used as the standard for calibration purposes. Spectral bins which contain apparent merchant lines will be analyzed for their statistical composition; samples of the amplitude for successive time records will be taken over the approximately 5 hours of signal duration and amplitude histograms produced. The data will be normalized to take out the range variations based on an attempt to fit a 20 log R variation (or something similar) to the amplitude trend versus range. Statistically significant numbers of samples will be taken to achieve desired confidence intervals on mean and variance. Chi-square goodness-of-fit tests will be applied for candidate pdf's. We will consider such distributions as Rayleigh, characteristic of fading environments, as well as the normal distribution.

Environmental Variables (U)

(U) Existing ambient noise and propagation loss models like FACT, PE, ASEPS will be used to relate environmental variables to statistical observables. Non-stationarity will play a key role here. For these types of time series, the autocorrelation function becomes a function of record length so new measures of signal coherence may be in order. The amplitude statistics will comprise the initial attempt at formulating relationships. Some attempt will be made to work with complex spectra and observe any variations of coherence versus range using both the autocorrelation and structure function constructs. This will involve looking at the frequency and phase statistics vs range as well as formulating the coherence measures.

Metrics (U)

(U) The establishment of corresponding metrics suitable to pattern recognition processes will be pursued at a rather low level initially, with only the most obvious considered for this initial analysis effort. Such metrics will probably be limited to signal duration, coherence, and line patterns.

Microstructure Spectral Analysis (U)

(U) If resources permit, the complex spectra data will be presented in a manner that will yield information relevant to theories like the JASON fluctuation theory. Received phasors (complex single spectral bin vectors—amplitude and phase) will be plotted in a scatter diagram format, and the resulting patterns investigated for characteristics indicative of saturated, unsaturated, and partially saturated propagation modes. The sensitivity of such patterns to range and frequency will be observed within the limits imposed by resources and analysis level of effort. Theories of fluctuation based on the work by Tataraki would be used to predict amplitude and phase pdf as functions of frequency and range if the data permit. The spectral patterns presented by merchant lines under fine-grain spectral analysis will be examined for characteristic features. Potential pattern recognition discrimination possibilities will be noted. Fluctuation spectra will be observed in the very narrowband analysis, and related to the fluctuation theories mentioned above.

ADDITIONAL TECHNIQUES TO BE INVESTIGATED (U)

(U) Various other signal processing and statistical techniques will be assessed for their applicability on a secondary-priority basis. Included among these techniques are the following.

Tone Estimation (U)

(U) Existing spectral moment estimation techniques will be validated as to their applicability and ease of implementation. These techniques are theoretically capable of providing estimates of the presence of narrowband tones even within the narrowband basic FFT frequency bins.

Goertzel Algorithm (U)

(U) The Goertzel algorithm provides a means for obtaining the equivalent of an FFT cell of specified resolution on a single bin-at-a-time basis. This algorithm may prove useful in investigating specific sections of the spectra without resorting to large FFTs.

Deconvolutional Filtering (U)

(U) The potential application of non-linear filtering deconvolution techniques, sometimes referred to as homorphic processing in the literature, will be investigated on a very low key basis for their use in the channel modeling problem. The cepstrum is a specific example of such a technique. Eventual use of such methods will allow the use of matched filter techniques, which are optimum only in the case of additive noise, to be applied as optimum non-linear filters against such things as multiplicative noise.

Maximum Entropy Techniques (U)

(U) This technique has been written about lately for its use in more efficient spectrum estimation. A tentative survey of the technique and its possibility for improving the spectral estimates will be made.

Structure Function (U)

(U) First developed by the Russians (including Kolmogorov and Tatarski) structure function has been used successfully to predict amplitude and phase metrics like sigmas, correlation periods, and even fluctuation spectra as a function of noise and frequency. The region of validity of such a tool should be established.

4. DATA BASE SURVEY AND EVALUATION (U)

(U) The LRAPP data base has been analyzed for applicability to the problem of interest. Figure 3 summarizes the overall data base review.

CRITERIA FOR USEFULNESS (U)

(U) The data base has been evaluated for its usefulness in characterizing the narrowband noise environment, particularly that noise which can be attributed to narrowband shipping lines. Accordingly, the data have been characterized regarding the following:

- Relevance to objectives of this study,
- Known presence of merchant lines,
- Availability of ancillary information, and
- Data format, quality, and availability.

In assessing the data, use was made of the LRAPP subpanel reports presented at the Woods Hole Conference on June 4, 1976. The panels assessed the data from past exercises in terms of usefulness for further post-experiment analysis relevant to the goals of each subpanel. The categories considered relevant to the present investigation which were explicitly taken into account by the subpanels were:

- Propagation Loss Subpanel
  - Signal fluctuations
  - Arrival structure
- Ambient Noise Subpanel
  - Fluctuations (noise decorrelation times, fluctuation spectra)
  - Environmental acoustic elements (wind noise, etc.)
- ASW Systems Requirements Subpanel
  - Time dependence of ambient noise
  - Analysis of ambient noise microstructure
  - Density of interfering lines
  - Second order statistics
  - Line bandwith vs range.

EXERCISE EXPERIMENT	PRINCIPAL ORGANIZATION: NRL	NUC	NUSC	USI	ARL	TRACOR	TETRA TECH	ARC/IDM
CHURCH OPAL	S. MARSHALL λ DATA W-K FORMAT 64 CH MUX ON 32 TRK RECORDINGS	R. WAGSTAFF B. KOLESAR E. TUNSTALL CVB ANALOG TAPES ANNOTATED GRAMS AND TASS DATA		D. HECHT M. WEINSTEIN CVB DAAPAN TAPES, 256CH MUX÷14	J. SHOOTER OMNI RECORDINGS AND DIGITIZE FFTs WITH 6 HOURS OF A A MERCHANT ACODAC ABOVE AND BELOW CRITICAL DEPTH			
CHURCH ANCHOR								
MED IV EXTENDED						A. WITTENBORN J. GOTTWALD TASS DATA 14 TRK ANALOG		
FMS							W. LABUDA PROCEDURES DOCUMENT DESCRIBES DATA BASE	ARCHIVED TAPES, VARIOUS SOURCES, FIXED AND MOBILE BEAM DATA
BERMUDA			D. COBB 2 MIN/HOUR BEAM DATA					

Figure 3. SUMMARY OF EXERCISES AND ORGANIZATIONS CONTACTED FOR NARROWBAND NOISE DATA BASE (U)

(U) In accordance with this assessment, the following exercises were determined to be the most useful for further study:

- Church Opal
- FME
- Church Anchor
- Task IV extends of Med 74 exercise.

(U) These data sets represent a common geographic area of high interest, the Northeast Pacific. Tapes and data, processed to varying degrees, are currently held by the organizations shown in Figure 3.

DATA DESCRIPTION AND EVALUATION (U)

(U) This information will be published in a separate letter report later this month.

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
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SUITE 1425
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Encl: (1) List of DECLASSIFIED LRAPP Documents

1. In accordance with reference (a), a declassification review has been conducted on a number of classified LRAPP documents.

2. The LRAPP documents listed in enclosure (1) have been downgraded to UNCLASSIFIED and have been approved for public release. These documents should be remarked as follows:

   Classification changed to UNCLASSIFIED by authority of the Chief of Naval Operations (N772) letter N772A/6U875630, 20 January 2006.

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55	Weinstein, M. S., et al.	SUS QUALITY ASSESSMENT, SQUARE DEAL	Undersea Systems, Inc.	750207	ADA007559; ND	U
BKD2380	Unavailable	WESTLANT 74 PHASE 1 DATA SUMMARY (U)	B-K Dyanmics, Inc.	750301	NS; ND	U
TM-SA23-C44-75	Wilcox, J. D.	MOTION MODEL VALIDATION FROM LRAPP ATLANTIC TEST BED DATA	Naval Underwater Systems Center	750317	ND	U
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PSI TR-004018	Barnes, A. E., et al.	ON THE ESTIMATION OF SHIPPING DENSITIES FROM OBSERVED DATA	Planning Systems Inc.	750401	~~ND~~ AD C096582	U
NUSC TD No.4937	LaPlante, R. F., et al.	THE MOORED ACOUSTIC BUOY SYSTEM (MABS)	Naval Underwater Systems Center	750404	ADB003783; ND	U
USI 460-1-75	Weinstein, M. S., et al.	SUS SIGNAL DATA PROCESSING (U) INVESTIGATIONS CONDUCTED UNDER THE DIAGNOSTIC PLAN FOR CHURCH ANCHOR AND SQUARE DEAL SHOT DATA (U)	Underwater Systems, Inc.	750414	ADC002353; ND	U
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TTA83676285	Unavailable	ANALYSIS PLAN FOR NARROWBAND/ NARROWBEAM AMBIENT NOISE (U)	Tetra Tech, Inc.	761112	ADC008275; NS; ND	U
USI 564-1-77	Wallace, W. E., et al.	REPORT OF CW WORKSHOP. NORDA, BAY ST. LOUIS, MISS., 28-29 SEPT 1976	Underwater Systems, Inc.	770124	ND	U